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(19) (CA) **CANADIAN PATENT** (12)

(54) Data Carrier Having a Liquid Crystal Security Element

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Abstract

A data carrier such as an identity card or a paper of value protected against attempted forgery using color copiers and containing an optically variable security element made of a liquid crystal material. The security element, e.g. a safeguarding thread, has a plastics-like layer made of a liquid crystal polymer which shows a pronounced play of colors at room temperature. The plastics-like properties of liquid crystal polymers permit easy processing into a semifinished product or into the finished product, so that completely different types of security elements can be produced.

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A data carrier having a liquid crystal security element

The present invention relates to data carriers, in particular papers of value, documents, identity cards or the like, having an optically variable security element containing a liquid crystal material. For easier readability the abbreviation "LC" will be frequently used in the following for "liquid crystal."

The increasing technical maturity of color copiers leads to copies that are ever more difficult to distinguish from the originals in color, resolution and quality. To protect data carriers from being forged with the aid of color copiers or scanners, optically variable elements are being used more and more as security elements. Such elements have in common that they exhibit different colors or brightnesses depending on the lighting and viewing conditions. The commonest optically variable elements are diffraction grids, holograms, interference coatings, metameric inks and polarizing coatings.

Holograms and grids are based on diffractive effects. Interference coatings usually comprise several superjacent layers, the layer thicknesses being within the size of the wavelength of the light.

Metameric inks customarily consist of mixtures of pigments with different reflectance bands. This composition causes the metameric inks to change their visual color effect when the type of lighting changes.

Dichroic dyes have the property of absorbing white light in different wave ranges depending on the polarizing direction. The result is a polarization-dependent color effect.

The disadvantage of the known optically variable authenticity features is that they are very expensive to produce, cannot be processed using conventional production methods or are not fully compatible with other authenticity features or card elements.

The invention is based on the problem of proposing a feature effective as copying protection that has effects dependent on the viewing angle, can be produced inexpensively and using conventional methods and is compatible or combinable with other features.

This problem is solved by the features stated in the characterizing part of the main claim. Developments are stated in the dependent and independent claims.

The invention is based on the use of liquid crystal polymers as security elements. After suitable oriented production these polymers constitute at room temperature a plastics-like solid with a pronounced play of colors. A suitable production method is, for example. to doctor the material while still liquid onto a base and subsequently harden it by UV irradiation. Suitable liquid crystal polymers are in particular liquid crystalsilicone polymers and cholesteric organopolysiloxanes. Their chemical structure and production are described in the published patent applications EP-A 0 136 501, EP-A 0 060 335 and European patent no. 0 066 137. The disclosed content of these publications is expressly referred to.

The use of conventional liquid crystals as security elements is already known and is proposed, for example, in Australian patent no. 488 652 (Commonwealth). This reference describes a laminated bank note with an intermediate layer in which a security element is embedded in the form of a liquid crystal material. The LC material is applied to an inlay by printing technology. The liquid crystals are in a liquid state of aggregation, are embedded in microcapsules closed on all sides and mixed into an ink. The test for authenticity involves a change of color of the security element due to a change of temperature.

Despite a structural anisotropy, liquid crystals customarily behave like liquids, which is why it is necessary to enclose these materials in capsules or cavities. This results in complicated production engineering. Not only is the encasing of the LC materials elaborate, it is also impossible to embed the proposed security elements in films or identity documents in the conventional way under the action of pressure and heat (classical laminating technique) due to the danger of injuring the cavities or capsules. Encased liquid crystals are also unsuitable as security ele-

ments on bank notes or papers of value with steel intaglio printing since the high pressure stresses required in this production method lead to destruction of the capsules and cavities.

However. after corresponding processing liquid crystals can also be present in a solid form and exhibit a high-grade orientation of their molecules depending on the processing method: making their optically variable properties stand out to their full extent and in full brilliance. In the inventive LC systems the color purity of the reflected light only rarely exceeds a range of 100 nm. the color change effects upon a change of viewing angle are very pronounced, and the reflected and transmitted light has a pronounced circular polarization. These fully developed optically variable properties make such LC polymers particularly suitable for use as security elements on data carriers. papers of value and identity cards. The plays of color are easily observable even for the layman. The wavelength-selective reflectivity and the polarization effects make the material highly suitable for automated testing. The multiplicity and pronounced character of the optical effects makes it difficult to prepare simulacrum counterfeits. In virtually all embodiments the LC elements can be additionally employed both as machine-readable authenticity features and together with other machine features. Due to the IR permeability of LC polymers the other machine features might also be disposed under the LC polymers.

The solid properties of LC polymers make it considerably easier to produce security elements from them. Firstly, it is unnecessary to enclose the liquid crystals in a hollow body. Secondly, there is no danger of bursting and of the liquid crystals leaking out during following processing steps and during the life of the data carrier. This makes the production processes and application extremely uncomplicated.

The plastics-like properties of liquid crystal polymers allow for easy processing into semifinished products or into the finished product. The starting material is generally present as granular material and can be shaped and processed with the methods and machines known from plastics production. This makes it possible in the field of security technology to produce completely different types of security elements on the basis of LC polymers and to cover different cases of application.

Thus, carrier webs made of tear-resistant plastics can be coated with a layer of LC polymers. The resulting web of material can then be cut into narrow webs or threads that can be embedded in paper or other substances as safeguarding threads.

Alternatively, multilayer webs of film can also be produced that contain an embedded layer made of an LC polymer. Such webs can be formed as adhesive or transfer bands that are suitable for gluing or stamping transfer elements onto paper or plastics surfaces.

Finally, LC polymers can also be produced as self-supporting films. These films can be used, for example, as layers of film for multilayer identity cards.

Further advantages and features of the invention can be found in the dependent and independent claims and the following exemplary embodiments and figures, in which

Fig. 1 shows the spectral transmission and reflection properties of LC polymers from various viewing angles,

Fig. 2 shows a bank note with a window safeguarding thread having one or more layers made of LC polymers,

Fig. 3 shows a safeguarding thread having a layer made of an LC polymer,

Fig. 4 shows a symmetrically constructed safeguarding thread having outside layers made of LC polymers,

Fig. 5 shows a symmetrically constructed safeguarding thread having inside layers made of LC polymers,

Figs. 6a, b show a printed, symmetrical window safeguarding thread in cross section and from the top,

Figs. 7a, b show a printed safeguarding thread having kinetic effects in cross section and from the top,

Figs. 8a. b show an identity card having a transfer element with an LC layer from the from and in cross section.

Figs. 9a. b show an identity card having a visually unreadable coding covered by the security element.

Fig. 10 shows a cross section through a transfer band.

Fig. 11 shows the transfer of an LC security element to a substrate.

Fig. 12 shows an identity card having a laminated-in layer made of LC polymer.

Fig. 13 shows a test assembly for LC security elements,

Figs. 14, 15 show detector assemblies for detecting LC security elements.

To make it easier to understand the applications and effects of liquid crystal polymers that are discussed in the Figures and exemplary embodiments, some important properties of these substances shall be explained in advance.

LC polymers are a special variant of liquid crystals in which the liquid crystalline state is "frozen" in a polymer matrix, so that the optical properties stand out particularly clearly. Thus, liquid crystal polymers normally absorb no light; their coloring arises by multiple interference of light on the individual crystal planes. The color effect in incident and transmitted light is accordingly different. The reflected color spectrum contains only a narrow frequency range about a central wavelength and thus shows a high color saturation. The transmitted spectrum is complementary to the reflected one and has a sag in the area about the central wavelength.

When LC polymers are used on opaque substrates one obtains a particularly high degree of color purity for all viewing angles if the liquid crystal layer is applied to a black background. The reflected spectrum is then not disturbed by secondary reflections on the background.

The lattice constants of inventive oriented LC polymers can be set. or defined during synthesis. to be in the range of 300 nm to 1.000 nm. so that the reflected central wavelength when vertically incident is in the near infrared or the visible range. As the viewing angle flattens. the central wavelength of the reflection band shifts in the direction of shorter wavelengths. For example, the perpendicular reflected wavelength is approx. 20% greater than reflection at 60°.

Fig. 1 shows spectral reflection R of an LC layer with vertically incident illumination in curve 1 and with a lighting direction of 60° in curve 2. For special LC polymers the color effect can accordingly change from green to violet, yellow to blue, light red to green or, with an IR reflection band from black to red. The lattice constant and thus the basic color of the liquid crystal polymer depends on the precise chemical structure of the liquid crystal and can be defined by the synthesis conditions to be in the range between 300 and 1.000 nm.

Fig. 2 shows an application of an LC polymer for a window safeguarding thread. In a bank note 11 with a security print 12 a safeguarding thread 13 has been embedded during the paper production in such a way that it comes to lie in windows 14 on the surface of the paper and is thus visually recognizable. Depending on the embodiment. the width of such safeguarding threads fluctuates between 0.5 and a few millimeters.

To give the bank note copying protection by optically variable effects, safeguarding thread 13 is designed in such a way that it contains one or more layers made of an LC polymer. Variants for producing and constructing safeguarding threads are shown in Figs. 3 to 7.

Fig. 3 shows the cross section of a first variant for a safeguarding thread 13a. It comprises a plastics carrier 20, for which a polyester film with a typical thickness of 20 to 100 micrometers is preferably used. Carrier 20 is coated on one side with a several micrometer thick layer 21 made of an LC polymer. To bring out optically the plays of color of the liquid crystals, film 20 is preferably dyed black. The thread is oriented during the paper production in such a way that the liquid crystal layer is present on the visible outer surface.

Fig. 4 shows a cross section of a further variant of a safeguarding thread 13b with a symmetrical layer structure. Symmetrically constructed safeguarding threads have the advantage that the orientation of the thread need not be heeded when it is embedded in the paper. Thread 13b comprises two carrier films 20 that are both coated on one side with a layer 21 of LC polymers. Carrier films 20 are interconnected with a laminating agent 22 so as to give rise to a symmetrical layer structure with outside LC layers. To increase the wealth of color one can optionally dye carrier webs 20 and/or laminating agent 22 with transparent or pigment inks. A simple solution in terms of production engineering is to dye only laminating agent 22, preferably using an opaque black.

Fig. 5 shows a further variant of a symmetrically constructed safeguarding thread 13c in cross section. In contrast to Fig. 3, carrier films 20 now lie on the outer sides of thread 13c, thereby protecting inside LC layers 21 from being damaged. In this variant, preferably only the laminating agent is colored with a dye. Since outside carrier layers 20 must remain transparent they are colored either weakly or not at all.

Figs. 6a and 6b show a further variant of a safeguarding thread 13d in cross section (Fig. 6a) and from the top (Fig. 6b). As in Fig. 5, thread 13d has a symmetrical layer structure comprising two carrier films 20, two LC layers 21 and an adhesive layer 22. In the course of a production process the thread was joined together from two coated pairs of films 30, 31. Before joining, surface 33 of one of the pairs of films was furnished with a printed pattern 34 of black ink, alphanumeric marks being applied in microwriting to the surface of an LC polymer layer by a conventional printing method. A transparent laminating agent 22 was additionally used. In transmitted light the characters now appear black before the optically variable colored background of the polymer layer in the window areas of the paper. In incident light, however, only the micro-characters show a change of color.

In another variant of the safeguarding thread of Figs. 6a and 6b characters 34 are applied in green microprint to one of the LC layers while laminating agent 22 is dyed black. Simultaneously the LC material is selected so as to appear green at a certain viewing angle, for example perpendicular to the black background. When the safeguarding thread is

viewed at this angle the total surface then appears green. When the viewing angle changes, the color of the LC polymer layer changes. While in the writing the green color remains dominant. The result is a safeguarding thread whose writing is visible only when the thread is tilted.

It is of course also possible to orientate the liquid crystal material by doctoring. This could for example be done by doctoring or rolling the liquid crystal polymer onto the surface of the roller. The liquid crystal polymer is then transferred from the roller to the surface of the data carrier by a printing process.

Figs. 7a and 7b show a further variant 13e in cross section (Fig. 7a) and from the top (Fig. 7b). The safeguarding thread comprises a carrier film 20 and a layer 21 made of LC polymers. The polymer layer was printed with a pattern of different-colored diagonal stripes 40 by a conventional printing method. In the example shown, the special color sequence selected for pattern 40 was red 41, yellow 42, green 43, blue 44, the pattern being repeated any number of times over the length of the thread. When this safeguarding thread 13e is viewed, colored surface areas 40 appear through the LC layer with different color effects each time. The color spectrum of the individual areas is composed of the reflection bands of the printed dyes. In addition, the colors of the liquid crystal layer are admixed additively. Due to the angle-dependent reflection characteristics of LC polymers, the colored stripes with the arrangement shown can create the illusion of a colored stripe moving along the thread when the thread is tilted, if the colors of the LC polymer are suitably coordinated. As in Fig. 5, this variant can also be expanded into a safeguarding thread having a symmetrical layer structure.

The variants shown in Figs. 3 to 7 can be varied in manifold ways depending on the desired appearance. The optically variable effects of

LC polymers can be combined by dyeing any desired layers with "classical" inks, using et her transparent dyes or pigment dyes. The dyes themselves can be introduced into any layer (including the LC layer, but then only in a low concentration) of the safeguarding thread and/or applied as a printed pattern to any layer of the thread.

The ways of dyeing stated in the description of the figures are only intended by way of a proposal; the stated colors can be replaced at will by any other dyes. These possibilities of combination result in an enormous multiplicity of possible color variations, color illusions and kinetic effects.

The variants of safeguarding threads shown in Figs. 3 to 7 can all be

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produced on the basis of one semifinished product. The semifinished product is produced by coating a web of film 20 made of a carrier material such as polyester plastics with a layer 21 of LC polymers. Depending on the color design of the safeguarding thread, one uses printed, transparent or dyed carrier films. The thickness of the web of film is preferably in the range of less than one tenth of a millimeter; for the LC coating a film thickness of approx. 10 micrometers is usually sufficient. For manufacturing reasons the typical web widths of the semifinished product are in the range of one meter.

Printed safeguarding threads are produced by printing the desired patterns or characters on the carrier web and/or the LC layer by a suitable production method on known printing machines. Multilayer, especially symmetrically constructed safeguarding threads are produced by placing the coated and possibly printed webs of film one upon the other and connecting them with a laminating agent.

Only when the webs have the desired layer structure are they cut into the threads on known cutting apparatus. The final thread width is in the range of 0.5 to 5.0 mm depending on the desired application. The resulting threads are suitable in particular for being embedded in paper but can also be embedded between the plastics layers of an identity card.

Another class of security elements are transfer elements, which are frequently applied to credit cards, identity cards, bank notes, papers of value and the like to protect them from forgery and in particular from being multiplied by copying. For these purposes one can also use security elements based on LC polymers due to their optically variable properties. The transfer elements are transferred to the surface of the objects to be protected from carrier bands by the transfer method.

Figs. 8a and 8b show an identity card 50 with a symbolically represented data record 49 and a transfer security element 51 in a front view and a sectional view. Security element 51 contains a layer made of an LC polymer, which is why it has the plays of color typical of these materials.

Transfer elements customarily comprise several layers. Fig. 8b shows a section through the identity card along the line I/I. In the Figure the

height of the elements is highly exaggerated, it is usually only a few tenths of a micrometer. Substrate 53 bears successively an adhesive layer 54, a layer of protective lacquer 55, an LC layer 56 and final outside layer of protective lacquer 57. This security element, shown here in a very simple embodiment, can be varied in many different ways.

The possibilities for the color design of LC elements are analogous to those for safeguarding threads. If one desires clearly (visually) recognizable plays of color one preferably dyes the background black. To mix a color into the reflected spectrum one applied element 51 to a printed background 60, as shown in Fig. 8a. The printed pattern can varied in many ways: a simple design is a monochrome background: a polychrome printed background with contrasting alphanumeric characters or patterns such as brightly colored diagonal stripes, interpenetrating colored circles, etc., has an improved optical effect. Particularly interesting effects are obtained if background 60 contains a black and white or colored photograph, a signature and the like.

Similar color effects to the printing of the background can be obtained by dyeing, printing or writing on suitable optically effective layers of the transfer element, that do not change during transfer.

As will be explained below, the transfer principle makes it possible to give the optical element any desired outer contour. The coat of arms shape 61 shown in Fig. 8 is therefore representative of a stripe, a seal, a company logo, an alphanumeric character, numbering, a guilloche pattern, etc. The shape of outline 61 gives the optically variable element an individual character.

Figs. 9a and 9b show a front view and a sectional view of an application variant in which card data are both inconspicuously camouflaged and protected from falsification by an LC element. LC polymers with readily visible plays of color are usually transparent in the infrared and can thus be easily combined with codings readable in the infrared range. In a first printing process a coding 72 was applied for this purpose to the surface of a card 70 with an IR-absorbent ink 71. In the next step this IR coding 72 was overprinted with an IR-transparent ink 73 that is opaque in the visible spectral range. In the last step an LC security ele-

ment 74 was then sealed onto opaque ink 73 in this area.

For manufacturing reasons one prefers the transfer principle for applying security elements made of LC polymers to the surface of a substrate. In a first method step a transfer band is produced, and in a second method step the security element is detached from the transfer band and connected with the substrate.

Fig. 10 shows the structure of a transfer band 100 in cross section, as is suitable for applying security elements with an LC layer to a substrate surface. A carrier film 101 bears successively a wax layer 102, a layer of protective lacquer 103, a layer made of an LC polymer 104, a color layer 105 and a heat-sealing layer 106. The carrier film is preferably made of a tear-resistant plastics polyester with a thickness in the range of less than one tenth of a millimeter. The other layers of a transfer band customarily have a thickness of a few micrometers to a few tenths of a micrometer. Layers 103 to 106 located on the wax layer form the subsequent security element. To obtain color effects one can dye or print the transfer band in various layers during its production.

To apply the security element to the substrate one places transfer band 100 with heat-sealing layer 106 on substrate 111, as shown in Fig. 11, and presses them. The pressing is performed with a heated transfer die 112 or alternatively with a transfer roll. Under the action of pressure and heat the heat-sealing layer bonds with the substrate. Simultaneously, separation layer 102 melts, allowing for carrier material 101 to be removed. The security element is bonded with the substrate only in the surface areas in which the separation layer has become liquid, i.e. only in the surface areas heated by the transfer die. In the other surface areas the layer structure and the carrier material remain firmly interconnected. When the carrier film is removed from the substrate the layer structure tears along contour edges 113 of the transfer die, whereby contour 113 of the transferred security element always corresponds to the contour of the press die. In this way one can also realize complicated contour structures such as company logos, block letters and the like. The process of heat-sealing as such is known and is described, for example, in German laid-open print no. 33 08 831.

LC polymers can also be made into films. In this form they are suitable in particular as large-surface or all-over security elements for multilayer identity cards.

Figs. 12a and 12b show by way of example a laminated identity card 120 comprising a paper inlay 121 and two outside thermoplastic cover films 122 and 123. The layers are pressed under the action of pressure and heat into a compact identity card. The card information is customarily printed on the inlay that, in the example shown, has a picture of the owner 124, card data 125 and a company logo 126. The protection from forgery was increased by integrating a film made of LC polymer 127 into the card structure between the inlay and the upper cover film in the left half of the card. The plays of color of the liquid crystal film can be observed through the transparent cover film, whereby color-printed company logo 126 provides additional color effects.

Some LC compounds crosslink under the action of high-energy (e.g. UV) radiation and only then form a chemically stable film. Unexposed, i.e. unhardened, areas can be removed with solvents. In analogy to the known photographic methods of semiconductor and printing plate production one can thus expose a predefined surface of an LC film through a mask and then remove the coating chemically in the unexposed areas, thereby creating patterns, letters, numbers, etc.

It is of course also possible to cover the entire card surface with the liquid crystal polymer film. As an alternative to integrating a film into the card structure one might prefer to transfer the liquid crystal element to the inlay before lamination by the transfer principle. A further variant is to replace one or both cover films 122, 123 as a whole by an LC film in the usual structure of laminated cards.

Films made of LC materials are suitable as large-surface or all-over security elements. Such films are preferably made from a liquid crystal substance. To obtain a film suitable for security purposes one processes the LC substance on a roller frame. The orientation of the liquid crystal molecules necessary for the optical effects is effected by shearing forces that occur during rolling. The resulting film material is suitable in particular for the production of identity cards but can also be used for

other authenticity marks. such as safeguarding threads.

For automatic testing of authenticity marks based on the inventive liquid crystal polymers, their polarization properties and their wavelength selectivity are particularly suitable. The reflected light is initially constricted spectrally to a range about the central wavelength. and unpolarized light is also broken down in liquid crystal polymers into right- and left-handed components. Depending on the chemical composition of the polymer only one of the components is reflected, while the complementary component is transmitted.

One possibility of automatic testing shall be shown in the following with reference to an LC polymer film located on a black, completely absorbent carrier 128. As shown in Fig. 13, element 130 is illuminated at a predetermined angle with an unpolarized light beam 131. for example an incandescent lamp 129. After reflection, light beam 132 hits detector system 133 shown in Fig. 14 used for detecting the spectral filtering and the circular polarization.

The structure of detector system 133 is shown in Fig. 14. Within detector system 133 reflected beam 132 initially passes through a color filter 141. that only lets through light of the expected central wavelength. The light beam then hits a lambda/4 plate 142 that converts the circular polarization into a linear polarization. The light then hits a 1:1 beam splitter 143, from where two partial beams 144, 145 reach two detectors 146, 147 with polarizing filters 148, 149 disposed therebefore. Planes of polarization 150, 151 of the two filters are perpendicular to each other, while being aligned at 45° with the two optical axes of the lambda/4 plate.

The automatic authenticity testing is based on an analysis of the two detector signals. The mode of functioning of the detector system is shown in the following with reference to several cases.

A) Authentic element

The reflected light passes the color filter without hindrance. In the lambda/4 plate a linear, either horizontal or vertical, polarization is pro-

duced from the circular polarization. The linear polarization causes one of detectors 146, 147 receive the full intensity while the second detector receives no light.

B) Forged element with unpolarized reflection

The spectrally correct but unpolarized reflected light has no preferred polarizing direction even after passing the lambda/4 plate. Each detector receives 50% of the reflected light.

C) Forged element with spectral error

The reflected light is absorbed in color filter 142 and accordingly neither of the detectors receives a signal.

D) Forged element with linear polarization

The 45° arrangement of the lambda/4 plate and the two polarizers causes both detectors to receive the same signal regardless of the original polarizing direction of the reflected light.

To increase the error significance one can also employ several detector systems for testing one element, the systems being disposed for example at different angles and accordingly reacting to different central wavelengths.

It is clear to the expert that the detector system can be realized in many different ways. Fig. 15 shows, as an easy-to-service alternative, an arrangement using optical fibers. The basis of the optical arrangement is again Fig. 13. In detector system 133, reflected light beam 132 initially passes through a color filter 161 to check the central wavelength. In following lambda/4 plate 162 the circular polarization is converted into a linear one. An input coupling optical system 153 couples light beam 132 into a waveguide system 154, known beam separators separate the beam into equivalent partial bundles. At the end of each partial bundle there is a polarizer-detector pair 155/156 and 157/158 for the two different polarizing directions.

If the light has the correct wavelength and polarization one of the two detectors 156/158 receives (in the case of lossfree optics) 50% of the input intensity, the second receives no light. In the case of a forged element reflecting unpolarized light, each of the detectors receives 50% of the input intensity. In this way one can distinguish forgery from the original.

Claims:

1. A data carrier, in particular a paper of value, document, identity card or the like, having an optically variable security element containing a liquid crystal material, characterized in that the material is a liquid crystal polymer which is present in an oriented form and at room temperature as a solid.

2. The data carrier of claim 1, characterized in that the material is a crosslinkable liquid crystal-silicone polymer.

3. The data carrier of claim 1, characterized in that the material is an organopolysiloxane or an organooxysilane or a compound with an organopolysiloxane or an organooxysilane.

4. The data carrier of claim 1, characterized in that the liquid crystal polymer is present as a layer or a film in the security element or in the data carrier.

5. The data carrier of claim 4, characterized in that the carrier films (20) coated with liquid crystal polymer are joined together in pairs with a laminating agent (22) so as to give rise to a symmetrical layer structure (13c, 13d).

6. The data carrier of claim 4, characterized in that at least one surface of the security element is printed with transparent absorbent and/or reflective inks (34, 40) or one layer of the security element is dyed with such inks.

7. The data carrier of claim 6, characterized in that the security element is applied in a printed and/or inscribed area (60) of the data carrier.

8. The data carrier of claim 7, characterized in that a normally invisible coding (72) is applied to the data carrier in the area of the security element.

9. The data carrier of claim 8, characterized in that the liquid crystal polymer is processed as a film (127).

10. The data carrier of claim 9, characterized in that the film (127) is integrated as a security element into the structure of a multilayer data carrier (120).

11. The data carrier of claim 10, characterized in that the film is the cover film (122, 123) of the data carrier.

12. An optically variable security element for equipping data carriers with liquid crystal material, characterized in that the security element is designed as a multilayer transfer element with at least one layer (56) of liquid crystal polymers.

13. The security element of claim 12, characterized in that layers or surfaces of the transfer element are printed or dyed with transparent absorbent and/or reflective dyes.

14. The security element of claim 12, characterized in that the contour (61) of the transfer element has a predetermined shape in the form of a logo, seal, coat of arms, alphanumeric characters, guilloche pattern or the like.

15. A semifinished product for producing the security element of claim 12, characterized in that a layer (21) or a film (21) made of a liquid crystal polymer is applied to a carrier film (20).

16. The semifinished product for producing a security element of claim 15, characterized in that two coated carrier films (20) are joined

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together with a laminating agent (22) so as to give rise to a symmetrical layer structure.

17. The semifinished product of claim 15, characterized in that a layer or surface of the semifinished product is printed and/or dyed with dyes.

18. The semifinished product of claim 15, characterized in that it comprises at least a carrier band and a separation layer, a layer with liquid crystal polymer.

19. A method for producing the data carrier according to any one of claims 1 to 18, characterized by following steps:

- applying the liquid crystal material while still liquid to a carrier surface,
- orienting the liquid crystal material by the mechanical action of shearing forces,
- hardening the oriented material to a solid,
- introducing or applying the solid liquid crystal material into or onto the layer structure of the data carrier.

20. The method of claim 19, characterized in that the carrier surface is a separate carrier film.

21. The method of claim 19, characterized in that the orientation is performed by doctoring on the liquid crystal material.

22. The method of claim 19, characterized in that the carrier surface is a printing roller onto which the liquid crystal material is directly doctored or rolled and from which the liquid crystal material is transferred to a surface of the data carrier by a printing process.

23. The method of claim 19, characterized in that the hardening is performed by a predefined energy input.

24. The method of claim 23, characterized in that the energy input is provided by irradiation with UV or IR light.

25. The method of claim 23, characterized in that the energy input is provided by the action of an electron beam.

26. The method of claim 19, characterized in that the liquid crystal material forms a self-supporting film on the carrier surface and is detached after hardening.

27. A method for producing the data carrier according to any one of claims 1 to 18, characterized in that the liquid crystal material is disposed in an oriented and hardened form on a carrier film and is transferred from this carrier film to the data carrier or a layer of the data carrier by the transfer method.

28. The method according to any one of claims 19 to 26, characterized in that the hardening of the liquid crystal material is not performed over the entire surface but in the form of patterns, characters or the like, and the unhardened areas are removed after the hardening step.

29. The use of a liquid crystal polymer for protecting and/or identifying the authenticity of data carriers such as papers of value, identify cards or the like.

30. A method for automatically testing the data carrier of claim 1, characterized in that the security element is illuminated by a light

source from at least one predetermined angle, and the polarization properties and/or the spectral properties of the reflected light are tested by suitable detector assemblies.

31. The method of claim 30, characterized in that the properties of the reflected light are tested at several lighting and/or viewing angles.

32. An assembly for carrying out the method of claim 30 or 31, characterized by

- a light source (129) for illuminating the security element (130) from at least one predetermined angle,
- one or more color filters (141, 161) for testing the spectral properties of the reflected light,
- a polarization-optical component (152, 162),
- a beam splitter (143) for splitting the reflected light into partial beams of different polarization, and
- polarizing optical components (148, 149, 155, 157) and detectors (146, 147, 156, 158) for measuring the intensity of the partial beams.

33. The arrangement of claim 32, characterized in that the reflected beam (132) is coupled into a fiber-optical system (154) with an optical system (153), whereby the beam splitter and polarizing components (155, 157) are integrated into the system.

34. The data carrier according to any one of claims 1 to 7, characterized in that the liquid crystal polymer is processed as a film (127).

35. The security element of claim 13, characterized in that the contour (61) of the transfer element has a predetermined shape in the

form of a logo, seal, coat of arms, alphanumeric characters, guilloche pattern or the like.

36. The method of claim 27, characterized in that the hardening of the liquid crystal material is not performed over the entire surface but in the form of patterns, characters or the like, and the unhardened areas are removed after the hardening step.

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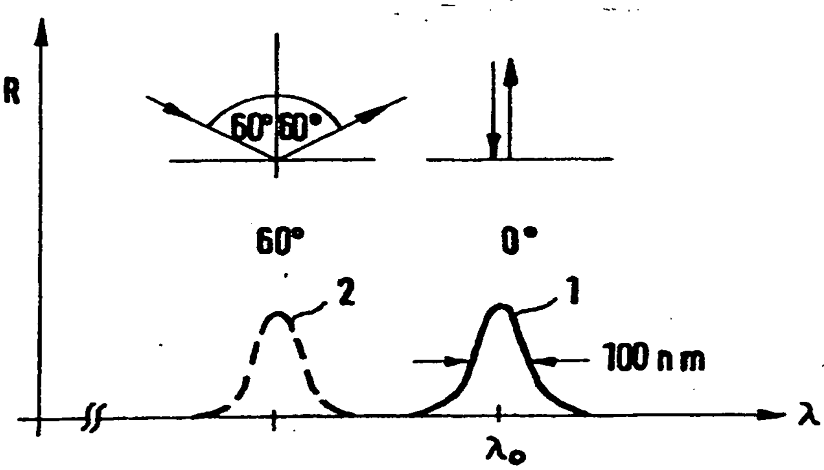

FIG.1

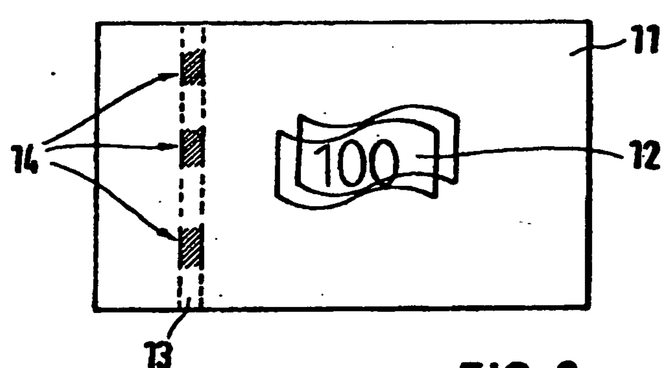

FIG.2

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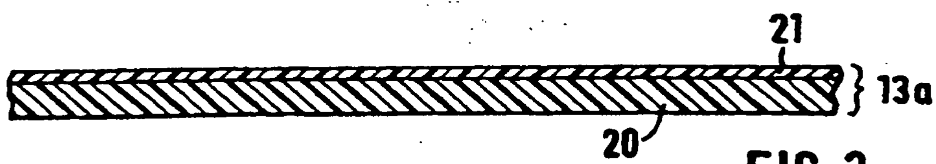

FIG.3

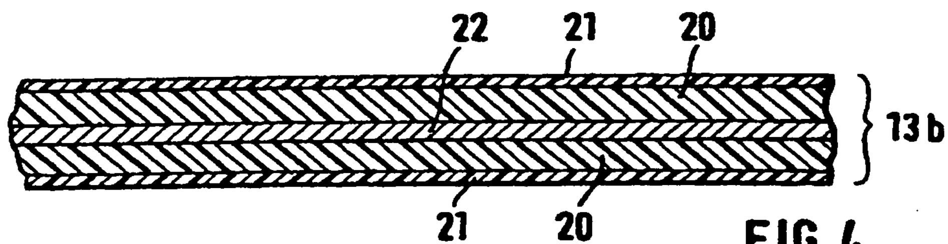

FIG.4

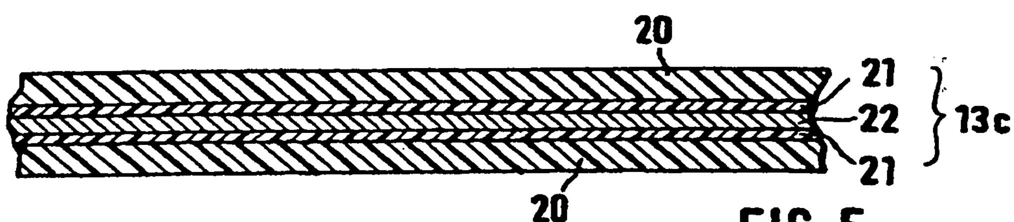

FIG.5

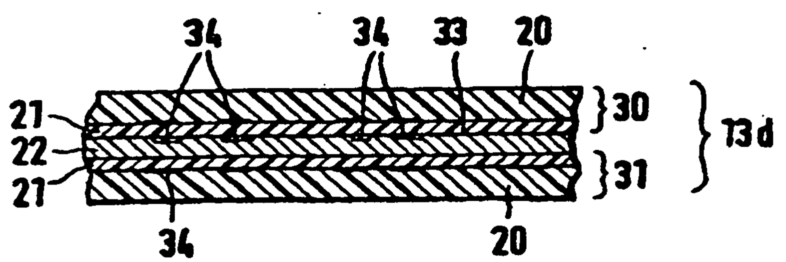

FIG.6a

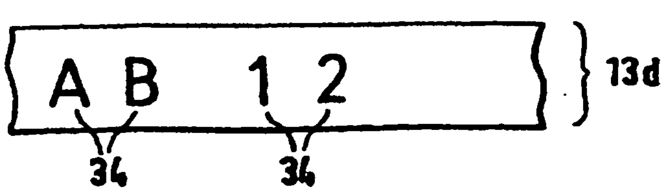

FIG.6b

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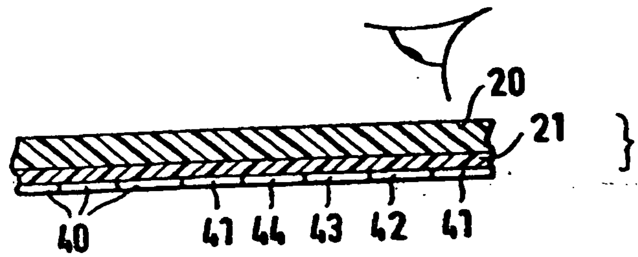

FIG.7a

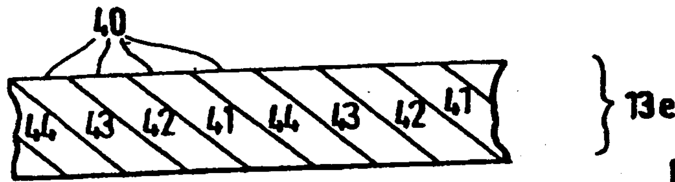

FIG.7b

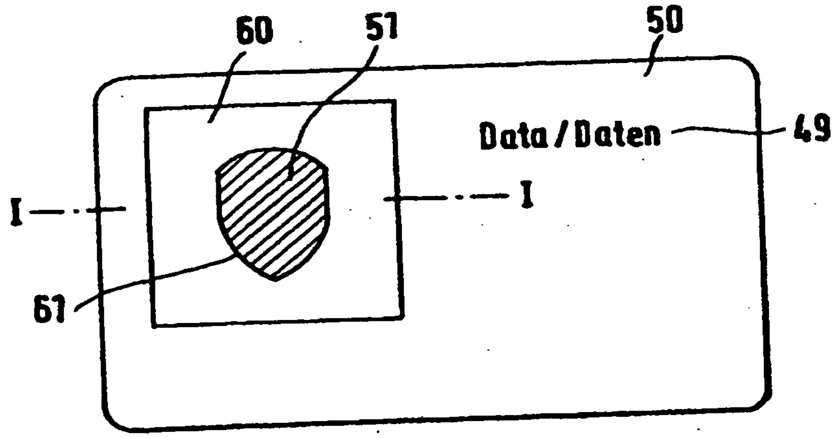

FIG.8a

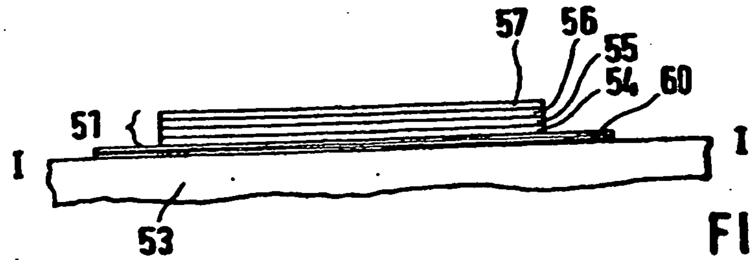

FIG.8b

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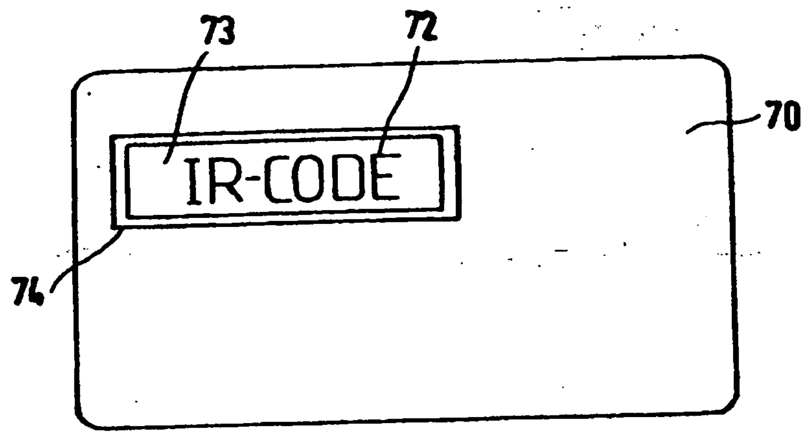

FIG. 9a

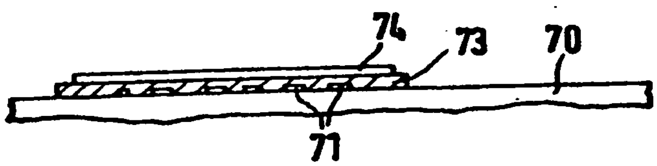

FIG. 9b

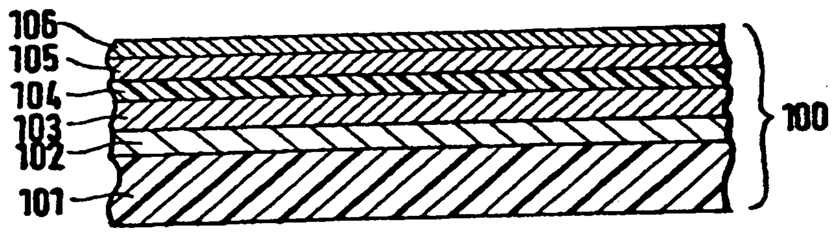

FIG. 10

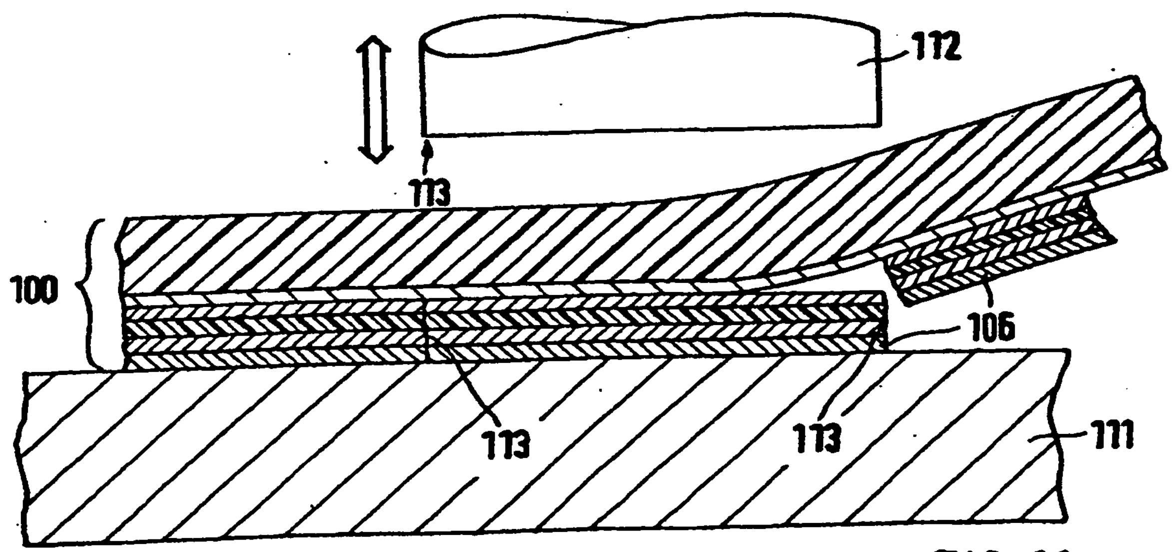

FIG. 11

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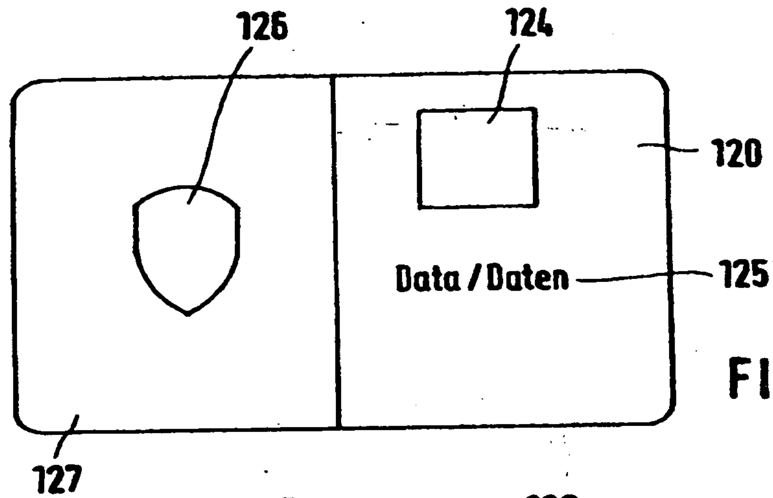

FIG.12a

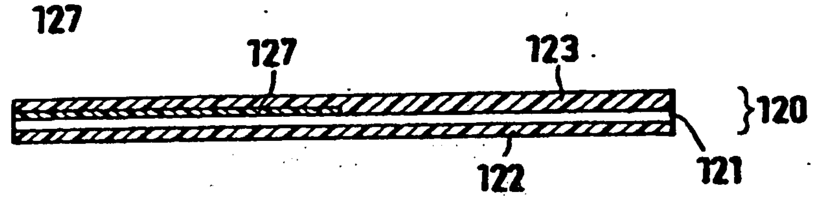

FIG.12b

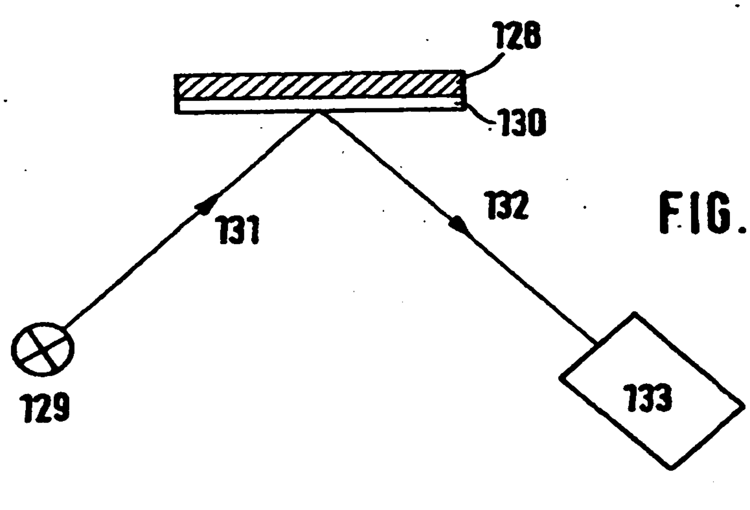

FIG.13

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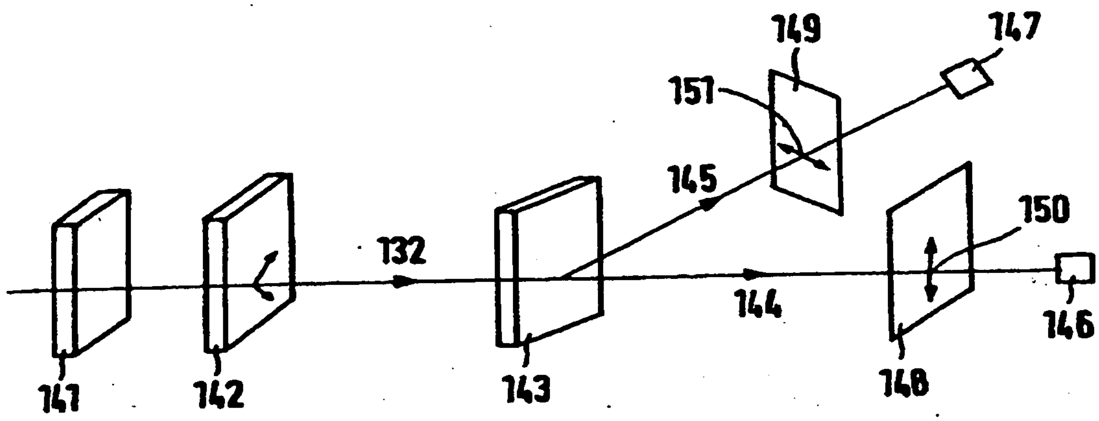

FIG. 14

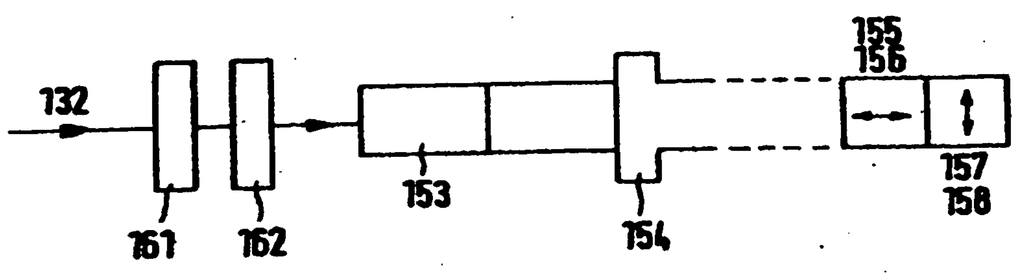

FIG. 15

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